

OPTICAL DEVICE INCLUDING TWO-DIMENSIONAL MATERIAL AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2015-0078239, filed on Jun. 2, 2015, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] Some embodiments relate to an optical device, and more particularly, an optical device configured to provide improved photo separation efficiency and a method of manufacturing the same.

[0004] 2. Description of the Related Art

[0005] In some cases, an optical device includes photodetector which includes a two-dimensional (2D) material layer, including a transition metal dichalcogenide (TMD) layer. The TMD material layer may absorb light, and electrons and holes generated by the absorbed light may move out to electrodes at both sides of the TMD material layer. In some cases, a photo absorption rate associated with a photodetector varies depending on a thickness of the TMD material layer and the TMD material layer may be formed as a relatively thick layer, as light absorption of the TMD material layer may be improved with increased thickness of the TMD material layer.

[0006] However, as layer thickness increases, electrons and holes generated in the TMD material layer may, in a process of moving through the TMD material layer out to electrodes at both sides of the TMD material layer, disappear after recombination due to their falling down to a conduction band and a valence band of the TMD material layer. In some cases, the movement of the electrons and holes through the TMD material layer may be at least partially hindered due to defects existing in the TMD material layer. As a result, photo separation efficiency of the TMD material layer, and thus the optical device, may be reduced with increased thickness of the TMD material layer.

SUMMARY

[0007] Provided is an optical device including a two-dimensional (2D) material which may be configured to increase both photo absorption rate and photo separation efficiency.

[0008] Provided is a method of manufacturing the optical device.

[0009] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of at least the presented example embodiments.

[0010] According to some embodiments, the optical device may include a barrier stack formed on a bottom channel layer, a top channel layer formed on the barrier stack, a drain electrode connected to the bottom channel layer, a source electrode connected to the channel unit, wherein the barrier stack may include the barrier stack including at least two barrier layers at least partially interposed by a channel unit. The barrier stack may include a first barrier layer and a second barrier layer placed over the first

barrier layer, and the channel unit, connected to the source electrode, between the first barrier layer and the second barrier layer

[0011] In the optical device, the barrier stack may further include a plurality of barrier layers at least partially interposed by separate channel layers connected to either the drain electrode or to the source electrode in an alternating interposing sequence.

[0012] At least one barrier layer of the first barrier layer and the second barrier layer may be at least one of a 2D material layer or a semiconductor layer.

[0013] The bottom channel layer may include a metal layer.

[0014] The bottom channel layer and the top channel layer may be doped in a first doping type, and the channel unit may be doped in a second doping type which is opposite to the first doping type.

[0015] When a distance that electrons and holes generated by photo absorption move ("travel") until recombination is defined as a particular distance, the thickness of each barrier layer of the first barrier layer and the second barrier layer may be less than the particular distance.

[0016] The bottom channel layer and the top channel layer and the channel unit may include 2D material layers in a single layer.

[0017] The bottom channel layer and the top channel layer may extend, relative to the channel unit, at a right angle, an acute, or an obtuse angle.

[0018] The source electrode may extend in a linear shape and the optical device may further comprise a plurality of drain electrodes corresponding to the source electrode.

[0019] At least one barrier layer of the at least two barrier layers may include a semiconductor layer, and the semiconductor layer may include at least one of a IV-group semiconductor, a III-V group compound semiconductor, an oxide semiconductor, a nitride semiconductor, or an oxynitride semiconductor.

[0020] The semiconductor layer may include at least one of a 2D semiconductor layer. The 2D semiconductor layer may include a metal chalcogenide-based material layer.

[0021] The semiconductor layer may include at least one of a 2D semiconductor layer, a quantum dot-contained layer, or a quantum dot layer. The quantum dot layer may include a plurality of quantum dots, and each quantum dot may include a core unit and a shell unit surrounding the core unit.

[0022] In a method of manufacturing an optical device according to some embodiments, a first channel layer may be formed on a substrate, and a first barrier layer and a second barrier layer may be sequentially formed over the first channel layer. A second channel layer may include a channel unit extended between the first barrier layer and the second barrier layer, and a third channel layer may cover an upper side surface of the second barrier layer and be connected to the first channel layer. Forming the second barrier layer on the first barrier layer may result in the channel unit at least partially interposing between the first barrier layer and the second barrier layer. A drain electrode may be formed on the first channel layer and a source electrode is formed on the second channel layer.

[0023] Prior to forming the third channel layer, at least one barrier layer may be laminated on the second barrier layer, and channel units connected to the source electrode and channel layers connected to the drain electrode may be